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Chromium picolinate supplementation in women: effects on body weight, composition, and iron status

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Abstract

Objective: This study tested the hypothesis that supplementation of chromium picolinate (CrPic), 200 μg Cr/d, compared with an equivalent amount of picolinic acid (1720 μg) in CrPic and placebo, decreases body weight, alters body composition, and reduces iron status of women fed diets of constant energy and nutrients.

Methods: We fed 83 women nutritionally balanced diets, used anthropometry and dual x-ray absorptiometry to assess body composition, and measured serum and urinary Cr and biochemical indicators of iron status before and serially every 4 wk for 12 wk in a double-blind, randomized trial.

Results: CrPic supplementation increased ($P < 0.0001$) serum Cr concentration and urinary Cr excretion compared with picolinic acid and placebo. CrPic did not affect body weight or fat, although all groups lost ($P < 0.05$) weight and fat; it did not affect fat-free, mineral-free mass or measurements of iron status.

Conclusion: Under conditions of controlled energy intake, CrPic supplementation of women did not independently influence body weight or composition or iron status. Thus, claims that supplementation of 200 μg of Cr as CrPic promotes weight loss and body composition changes are not supported.

Keywords: Chromium picolinate; Body fat; Lean mass; Women

Introduction

Rapidly increasing rates of overweight and obesity in the United States [1] have prompted individuals to seek weight-control products that are safe, convenient, and effective in promoting weight and fat loss and preserve muscle. The public seeks these products, principally dietary supplements [2,3], because they are perceived as less demanding to use than accepted lifestyle changes, diet, and physical activity in facilitating weight reduction or regulation [4]. Results from multistate and national surveys indicate that use of over-the-counter weight loss supplements is high (~10%), with the greatest use among young obese women [5,6].

Different dietary supplements are marketed for weight regulation including vitamins, minerals, and herbal and botanical compounds. Reviews of efficacy and safety of over-the-counter dietary supplements emphasize inconsistent evidence to support claims of weight reduction [2–4]. A popular dietary supplement marketed for weight regulation is trivalent chromium, specifically chromium picolinate [7]. Although other chromium-containing supplements are available, chromium picolinate is emphasized because of its high bioavailability and lack of toxicity [8]. Early reports that adults supplemented with chromium picolinate lost weight and body fat have not been confirmed [8,9]. Differences in experimental designs, including uncontrolled food and nutrient intakes and insensitive methods of assessment of body composition, complicate interpretation of the findings.

Chromium picolinate supplements may not be innocuous. Because chromium inhibits iron binding to transferrin

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[10,11], large intakes of chromium can impair iron transport and utilization [12]. In addition, picolinic acid is a potent metal-binding ligand with strong capacity to bind iron and other essential mineral elements [13]. Evidence of adverse effects of chromium picolinate supplementation on iron status of humans is contradictory [14,15].

This study examined the effects of chromium picolinate supplementation on body weight and composition and on blood biochemical indicators of iron nutritional status in women fed constant energy and nutrient composition diets. It tested the hypothesis that chromium supplementation decreases body weight, fat mass, measurements of iron status in women.

Materials and methods

Subjects

Eighty-three premenopausal women, 19 to 50 y of age with a body mass index range of 18 to 30 kg/m^2, completed all aspects of the study. Each volunteer completed a health questionnaire and had an interview with a nurse, screening blood assessment of health, urinalysis, measurement of body weight and standing height, and blood pressure to determine absence of anemia and no underlying health concerns. This study was approved by the University of North Dakota institutional review board and the U.S. Department of Agriculture Human Study Committee, and followed the guidelines of the Department of Health and Human Services and the Helsinki Doctrine regarding the use of human subjects. Written, informed consent was obtained from each volunteer before participation in the study.

Prospective subjects were recruited by advertisements in local media. All subjects lived in their usual residences and maintained their usual lifestyles during the study.

Experimental design

This study was a double-blind, randomized, controlled trial. After admission, volunteers were matched by body mass index and transferrin saturation and randomized into the treatment groups. During an initial 14-d period, all volunteers consumed the basal chromium diet (Table 1). This equilibration period was used to allow the women to adapt to the meal pattern and foods and to enable an initial estimation of energy needs to maintain body weight. For the next 12 wk, each woman received daily a commercially prepared capsule containing placebo (starch), chromium picolinate, or picolinic acid (Nutrition 21, Purchase, NY,

Table 1
Four-day rotating menu

Day 1	Day 2	Day 3	Day 4
Breakfast			
Orange juice	Orange juice	Skim milk	Orange juice
Skim milk	Pork sausage	Whole wheat bread	Skim milk
Oatmeal	Biscuit	Peanut butter	Shredded wheat
Brown sugar	American cheese	Strawberry jelly	White sugar
Wheat bagel		Mandarin oranges	Whole wheat bread
Cream cheese			Margarine
Strawberries			Blackberry jelly
			Blueberries
Lunch			
Skim milk	Apple juice	Beef patty	Baked chicken
Beef burrito	Turkey croissant	White hamburger bun	Lettuce/tomatoes
Refried beans	Mayonnaise	Ketchup	Carrots/ripe olives
Flour tortilla	Lettuce	Lettuce/tomatoes	Cheddar cheese
Cheddar cheese	Potato chips	Fritos	Ranch dressing
Lettuce/tomatoes	Lemon pie	Sugar cookie	Ritz crackers
Taco sauce			Pears
Sour cream			Butter mints
Brownie			
Supper			
Chicken and rice	Skim milk	Shrimp alfredo	Skim milk
Peas	Beef spaghetti	Lettuce/carrots	Beef potato cheese casserole
White dinner roll	Parmesan cheese	Ranch dressing	White dinner roll
Margarine	Romaine/ripe olives	Fruit cobbler	Margarine
Orange sherbet	Green pepper		Apple crisp
	Italian dressing		
	Angel cake		
Snacks			
Graham crackers	Pineapple tidbits	Skim milk	Vanilla ice cream
Red grapes		Angel cake	Caramel topping

USA) with breakfast. The capsules were similar in physical size and appearance. Chemical analyses found 187 μg of chromium in the chromium picolinate, 1720 μg of picolinic acid, and <2 μg of chromium in the placebo capsules.

The volunteers were weighed each morning before breakfast, Monday through Friday, on a calibrated scale. When necessary, energy intakes were adjusted to maintain body weight to within ±2.5% of estimated stable weight [16], determined before supplementation, by adjusting the amount of the basal diet in 200-kcal increments. Changes in food intake resulted in proportional changes in nutrient intakes.

Experimental diet

Registered dietitians planned the basal chromium diet; it contained ordinary Western foods presented in a 4-d rotating menu (Table 1). The energy distribution was 18% protein, 31% fat, and 51% carbohydrate that is consistent with the diet composition of the average adult in the United States [17]. All food was weighed during preparation in a metabolic kitchen. The volunteers were instructed only to consume the food and beverages provided by the dietary staff of the Grand Forks Human Nutrition Research Center. The dietary intake of each volunteer was based on energy needs calculated by the Harris-Benedict model [18] plus an additional 50% of basal energy expenditure for normal activity. The women ate breakfast at the center and consumed the remaining food away from the center on Monday through Friday. Weekend and holiday meals were provided for consumption away from the center.

Analyses of the experimental diet showed that the chromium content for the 4-d menu rotation was 29 ± 2 μg/d at an energy intake of 2000 kcal. Analysis of the experimental diet showed that the iron and copper contents were less than the recommended intakes [19]. Thus, the volunteers received 6 mg of iron as ferrous gluconate (Liquipharm Inc., Los Angeles, CA, USA) and 1.2 mg of copper in aqueous solution (JT Baker, Phillipsburg, NJ, USA) mixed into juice daily. The daily iron intake was 15 mg/d to accommodate increased iron loss associated with phlebotomy. The remaining composition of the diet was adequate in all other essential nutrients.

Biochemical assessments

Fasting venous blood samples and timed 24-h urine collections occurred at the end of the equilibration or baseline period and then regularly at the end of each 4-wk period during supplementation. Urine collections included the last 4 consecutive days of the last menu rotation of each 4-wk period. These urine collections were pooled to obtain a representative value for chromium excretion.

Care was taken throughout the study to avoid contamination of biological samples with environmental chromium. Blood samples were collected after an overnight fast by using chromium-free syringes (Safety Monovette, Sarstedt Inc., Princeton, NJ, USA) with siliconized needles connected to polyvinyl tubing (Minicath, Deseret Medical Inc., Sandy, UT, USA). The blood was allowed to clot in the syringes, centrifuged (1800 *g* for 10 min at 20°C) to collect the serum in a trace element-free laminar flow hood and then stored at −20°C in acid-washed, sealed polypropylene containers. Timed 24-h urine specimens were collected in acid- and deionized water-washed polyethylene containers. Dilute nitric acid rinses indicated no detectable chromium contamination in the containers. Urine-collection containers were shown to be chromium free after regular, multiple testing.

Chromium was analyzed by modifications of published procedures [20–22] by using graphite-furnace atomic-absorption spectrometry with Zeeman background correction (model 3030; Perkin Elmer Corp., Norwalk, CT, USA). The method of standard additions with 0.1% Triton X-100 and 0.25% magnesium nitrate as matrix modifiers was used. We found 7.9 ± 0.2 nmol/L in a control serum (UTAK Laboratories, Canyon Country, CA, USA) compared with a certified value of 7.7 ± 0.6 nmol/L. Recoveries of added chromium were 105.2 ± 4.2% from serum and 104.1 ± 4.1% from urine.

Hematocrit and hemoglobin were measured with a standard method and instrumentation (Abbott CELL-DYNE 3500, Abbott Park, IL, USA). Plasma iron and total iron-binding capacity were assayed by using a colorimetric method on a Cobas Fara centrifugal analyzer (Roche Diagnostic, Nutley, NJ, USA). Percentage of transferrin saturation was calculated from the serum iron concentration and total iron-binding capacity.

Duplicate diets at the intake of 2000 kcal were prepared daily during the last 4-d menu rotation of each 28-d period for analysis of chromium. The individual meal components were collected as a composite and then blended in plastic blenders with Teflon blades. The composite was freeze-dried and aliquots taken for analysis as described above.

Anthropometry and body composition

Standing height, without shoes or socks, was measured to the nearest 0.1 cm with a stadiometer (Harpenden, Pembrokeshire, United Kingdom) mounted on a wall. Body weight, without shoes, was determined on a calibrated scale (model 2831, Toledo Scale, Worthington, OH, USA) accurate to ±0.2 kg. Skinfold thicknesses were measured to 0.1 mm at the biceps, triceps, subscapular, and iliac sites on the right side of the body [23] with a Tanner-Whitehouse skinfold caliper (Harpenden) calibrated to exert a constant pressure of 10 g/mm^2.

Whole-body bone and soft tissue composition were measured with a QDR-2000W dual X-ray absorptiometer (Hologic, Inc., Waltham, MA, USA) using software version 7.1 to determine bone mineral content, fat mass, and fat-free, mineral-free mass based on attenuation of high- and

low-energy X-rays in the body. Technical variability of this device for repeated determinations of bone mineral content, fat mass, and fat-free, mineral-free mass was 1% [24].

Statistical methods

Power analysis was conducted to determine the number of volunteers required to achieve 90% power to detect a significant ($\alpha = 0.05$) interaction, based on the expectation that transferrin saturation would decrease 20% with chromium picolinate supplementation compared with 8% with placebo based on data from a previous study [14]. We estimated that 30 subjects were needed per group to detect a significant time-by-treatment interaction. Volunteer recruitment allowed for 20% attrition ($n = 36$ per group). Dropouts occurred when volunteers were unable to come to the center for meal consumption and pickup and to participate in regularly scheduled testing.

Values are presented as mean ± SE. A three-by-four repeated measures analysis of variance was used to determine the effects of supplementation (placebo, chromium picolinate, picolinic acid) and time (baseline, 4-, 8-, and 12-wk) on body weight, composition, and blood biochemical and urinary indicators of iron nutritional status and chromium intake. When a main effect was significant, Tukey's post hoc tests were used to identify significant differences. When a significant interaction was found, Bonferroni's contrasts were performed (SAS 9.1 for Windows, SAS Institute, Cary, NC, USA).

Results

Compliance

The volunteers consumed all capsules provided at breakfast at the center. They reported ingestion of all capsules provided for consumption away from the center.

Anthropometry and body composition

Age of the women at entry into the study was not different (33.0 ± 1.8, 30.7 ± 1.7, and 30.2 ± 1.5 y in the placebo, chromium picolinate, and picolinate supplemented groups, respectively). Similarly, the standing height was similar across groups (162.7 ± 1.0, 166.2 ± 1.0, and 165.7 ± 1.0 cm in the placebo, chromium picolinate, and picolinate supplemented groups, respectively). Energy intake was similar among the treatment groups. Supplementation did not affect body weight or body composition (Table 2). However, body weight and fat mass decreased significantly during the 12-wk intervention. The thickness of the four skinfolds also decreased significantly, which is consistent with the reduction in body fat mass. The average change in body

Table 2
Anthropometric, bone, and soft tissue composition measurements before and during 12 wk of controlled chromium diet and supplementation*

	Baseline	4 wk	8 wk	12 wk	RMSE	Supplementation	Time	Supplementation × time
Mass (kg)								
Placebo	63.4 ± 1.0	63.2 ± 1.0	62.6 ± 1.0	62.2 ± 1.0				
PA	63.9 ± 1.3	63.6 ± 1.2	63.3 ± 1.3	62.9 ± 1.3				
CrPic	65.6 ± 2.1	65.1 ± 2.1	64.8 ± 2.1	64.3 ± 2.1	0.7	0.596	0.0001	0.850
Test means	64.3 ± 0.9[d]	64.0 ± 0.9[c]	63.5 ± 0.9[b]	63.1 ± 0.9[a]				
BMC (kg)								
Placebo	2.10 ± 0.04	2.11 ± 0.04	2.11 ± 0.04	2.10 ± 0.04				
PA	2.15 ± 0.06	2.26 ± 0.12	2.17 ± 0.05	2.20 ± 0.05				
CrPic	2.24 ± 0.06	2.24 ± 0.05	2.24 ± 0.06	2.24 ± 0.06	0.14	0.232	0.307	0.365
FM (kg)								
Placebo	21.7 ± 1.0	21.2 ± 1.0	21.2 ± 1.0	20.3 ± 1.0				
PA	19.9 ± 1.1	19.5 ± 1.1	19.1 ± 1.1	18.6 ± 1.1				
CrPic	21.5 ± 1.0	21.1 ± 1.5	20.5 ± 1.5	20.4 ± 1.5	0.8	0.516	0.0001	0.145
Test means	21.0 ± 1.0[d]	20.6 ± 1.0[c]	20.3 ± 1.0[b]	19.8 ± 1.[a]				
FFMF (kg)								
Placebo	38.4 ± 0.7	38.7 ± 0.7	38.3 ± 0.7	38.6 ± 0.7				
PA	40.6 ± 0.6	40.6 ± 0.6	40.8 ± 0.7	40.9 ± 0.7				
CrPic	40.4 ± 0.9	40.7 ± 0.9	40.8 ± 0.9	40.5 ± 0.9	0.7	0.057	0.278	0.114
Σ4 SF (mm)								
Placebo	53.7 ± 2.2	53.1 ± 2.2	52.7 ± 2.2	51.7 ± 2.2				
PA	49.2 ± 2.5	48.1 ± 2.3	47.7 ± 2.3	47.1 ± 2.3				
CrPic	51.3 ± 2.8	51.2 ± 2.9	50.8 ± 2.7	49.3 ± 2.8	1.6	0.387	0.0001	0.535
Test means	51.5 ± 1.4[d]	50.9 ± 1.4[c]	50.5 ± 1.4[b]	49.4 ± 1.4[a]				

BMC, bone mineral content; CrPic, chromium picolinate; FFMF, fat-free, mineral-free mass; FM, fat mass; PA, picolinic acid; RMSE, root mean square error; Σ4 SF, sum of triceps, biceps, subscapular, and abdominal skinfold thicknesses

* Values are mean ± SE. There were 29 subjects in the placebo group, 27 in the PA group, and 27 in the CrPic group. Test means with different superscripts are statistically different, $P < 0.05$.

Table 3
Blood biochemical indices of iron nutritional status before and during 12 wk of controlled diet and supplementation

	Baseline	4 wk	8 wk	12 wk	RMSE	Supplementation	Time	Supplementation × time
Hemoglobin (g/L)								
Placebo	138 ± 1	138 ± 1	137 ± 1	139 ± 1				
PA	137 ± 1	138 ± 1	135 ± 1	137 ± 1				
CrPic	138 ± 1	138 ± 1	137 ± 1	139 ± 1	3	0.754	0.009	0.914
Test means	138.0 ± 0.8^{b}	137.8 ± 0.8^{ab}	136.6 ± 0.8^{a}	138.1 ± 0.7^{b}				
Hematocrit (%)								
Placebo	40 ± 1	40 ± 1	40 ± 1	41 ± 1				
PA	40 ± 1	40 ± 1	40 ± 1	40 ± 1				
CrPic	41 ± 1	40 ± 1	40 ± 1	41 ± 1	1	0.669	0.031	0.765
Test means	40.4 ± 0.2^{a}	40.3 ± 0.2^{ab}	40.1 ± 0.2^{a}	40.7 ± 0.2^{c}				
Iron (μmol/L)								
Placebo	13.1 ± 0.9	13.4 ± 0.9	14.0 ± 1.0	14.7 ± 1.1				
PA	12.5 ± 0.7	13.3 ± 0.9	13.7 ± 1.1	13.2 ± 0.9				
CrPic	10.6 ± 0.6	11.3 ± 0.7	12.2 ± 0.8	12.7 ± 0.9	3.3	0.084	0.013	0.875
Test means	12.0 ± 0.5^{a}	12.6 ± 0.5^{ab}	13.3 ± 0.6^{ab}	13.6 ± 0.6^{b}				
TIBC (μmol/L)								
Placebo	292 ± 8	288 ± 9	304 ± 9	308 ± 10				
PA	289 ± 9	283 ± 10	291 ± 10	283 ± 11				
CrPic	296 ± 9	293 ± 11	290 ± 10	300 ± 10	25	0.645	0.109	0.102
Transferrin saturation (%)								
Placebo	26 ± 2	26 ± 2	27 ± 2	27 ± 2				
PA	24 ± 1	26 ± 2	27 ± 2	27 ± 2				
CrPic	21 ± 2	22 ± 2	24 ± 2	24 ± 2	6	0.128	0.050	0.960
Test means	24 ± 1^{a}	25 ± 1^{ab}	26 ± 1^{ab}	26 ± 1^{b}				

CrPic, chromium picolinate; PA, picolinic acid; RMSE, root mean square error; TIBC, total iron-binding capacity
* Values are mean ± SE. There were 29 subjects in the placebo group, 27 in the PA group, and 27 in the CrPic group. Test means with different superscripts are statistically different, $P < 0.05$.

weight was about 1.2 kg or <2% decrease from baseline. Bone mineral content and fat-free, mineral-free mass did not change with supplementation or time.

Biochemical determinations

All measurements of iron nutritional status were within the range of normal values. Hematocrit and hemoglobin were not affected by supplementation or time, with a modest decline in the middle of the study in all women (Table 3). Supplementation did not affect serum iron concentrations or total iron-binding capacity. However, serum iron concentrations increased significantly during supplementation in all groups. Transferrin saturation, although not affected by supplementation, increased significantly over time, in parallel with serum iron.

Serum chromium concentrations increased significantly during supplementation with chromium (Fig. 1). Placebo-supplemented women had no change but women receiving picolinic acid had a slight but significant increase in serum chromium after 8 and 12 wk of supplementation. Urinary chromium excretion increased significantly only with chromium supplementation (Fig. 2).

Discussion

Chromium is provisionally considered to be a nutrient because of its putative roles in carbohydrate, protein, and lipid metabolism [25]; evidence indicates that chromium apparently facilitates the action of insulin [26]. Thus, chromium supplementation has been postulated to selectively decrease body fat and increase muscle or lean body mass [27]. Research to test this hypothesis has predominantly

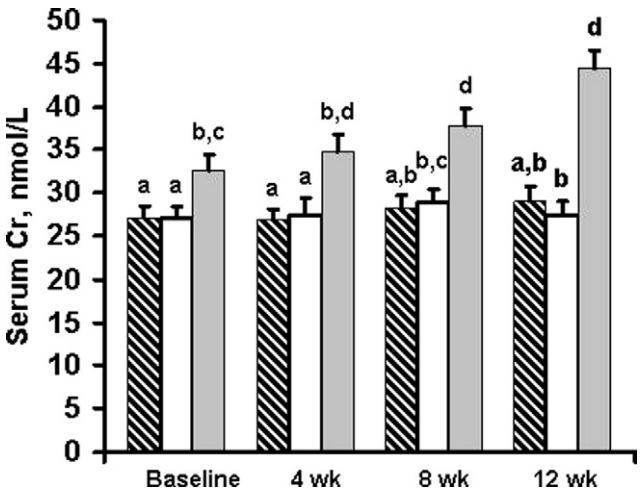

Fig. 1. Serum Cr concentrations at baseline and during 12 wk of supplementation. Values are mean ± SE. Hatched bars, placebo group ($n = 29$); open bars, picolinic acid group ($n = 27$); fully shaded bars, Cr picolinate group ($n = 27$). Analysis of variance results: supplement ($P < 0.0001$), time ($P < 0.0001$), supplement by time ($P < 0.0001$). Bars with different superscripts are statistically different, $P < 0.05$. Cr, chromium.

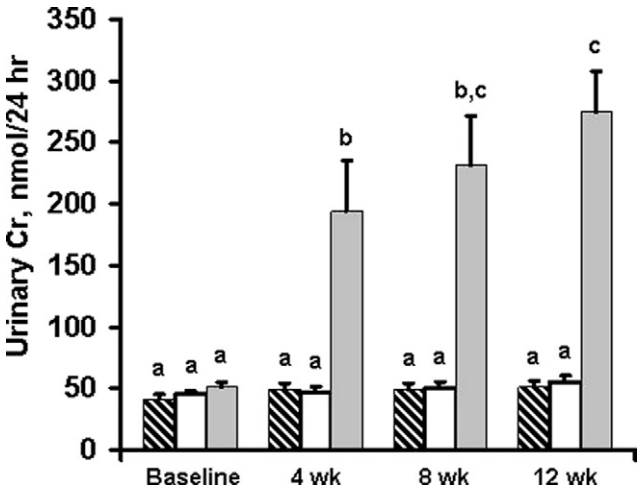

Fig. 2. Daily urinary Cr excretion at baseline and during 12 wk of supplementation. Values are mean ± SE. Hatched bars, placebo group ($n = 29$); open bars, picolinic acid group ($n = 27$); fully shaded bars, Cr picolinate group ($n = 27$). Analysis of variance results: supplement ($P < 0.0001$), time ($P < 0.0001$), supplement by time ($P < 0.0001$). Bars with different superscripts are statistically different, $P < 0.05$. Cr, chromium.

used chromium picolinate because it is better absorbed than other chemical forms of chromium and the ease of delivery of chromium compared with food sources [8]. Results from supplementation trials in animals and humans provide inconclusive support for this hypothesis [8,9]. The findings of the present study show no independent effect of chromium picolinate supplementation on loss of weight and fat and concomitant gain of lean body mass in adults fed controlled diets.

Early studies examined the additive effects of chromium picolinate supplementation (200 μg Cr/d) and resistive exercise training on body composition and strength gain of sedentary young men and women. Although one study reported increased body weight, lean body mass, and body fatness in collegiate men [28], later studies did not replicate the expected changes in body weight or composition under the same interventions [14,29,30]. These studies also found no meaningful effects of chromium supplementation on strength gain. Chromium supplementation trials (1000 μg/d for 8–13 wk) of older men and women also found no beneficial effects on body composition or strength [31–33].

Chromium supplementation studies of athletes also have yielded contradictory results. Among collegiate football players supplemented with chromium picolinate (200 μg Cr/d), one study [28] reported significantly decreased body fatness and increased lean body mass, whereas another study [34] found no difference in changes in body composition during 12 wk of physical training, compared with men given placebo. Collegiate wrestlers did not increase fat-free mass or lose body fat when supplemented with chromium during a 10-wk preseason strength-training program [35]. Female athletes supplemented with 500 μg of chromium (chromium picolinate) daily during 6 wk of preseason training had no improvement in body composition compared with their team-mates treated with placebo [36]. None of these studies reported a benefit of chromium picolinate supplementation on strength gain. Thus, supplementation of chromium to men and women participating in intensive sport training did not exclusively promote fat loss or boost muscle and strength.

No benefit of chromium picolinate supplementation on weight loss or body composition has been reported in weight-loss studies. Chromium supplementation was investigated because of speculation that it would ameliorate metabolic perturbations inherent with insulin resistance and, thus, promote weight and fat loss. Dosages of chromium exceeded 200 μg/d. In an 8-wk weight loss program, adults supplemented with 400 μg/d of chromium as chromium picolinate or chromium nicotinate had similar gains in lean body mass; no control group was included [37]. Other studies did not confirm these findings. Overweight military personnel supplemented with chromium picolinate (400 μg/d for 16 wk) during an aerobic training program to lose weight had similar decreases in body weight and fat as placebo-treated participants [38]. Other studies have supported a failure of chromium picolinate supplementation (400 μg/d for 9–12 wk) to favorably influence body composition change during weight-loss interventions [39–43]. In contrast, two other studies [44,45] reported greater weight and fat loss with chromium picolinate supplementation (200–400 μg/d for 72–90 d) compared with placebo. In contrast to the previous studies that reported actual measurements of body composition [38–43], these studies [44,45] used self-reports of physical activity and adjusted body composition assessments to yield the reported changes in body fat and lean body mass.

Critical review of the studies that report favorable effects of chromium supplements on body composition identifies some specific concerns. One factor is the validity of the body composition assessments. The only studies to show a positive effect of chromium picolinate supplementation on body weight and composition used skinfold thickness measurements [28]. However, the present study and others [29,30,42] used skinfold thickness and found no selective effect of chromium picolinate on body composition. Thus, it is reasonable to conclude that a potential error in the measurement of skinfold thickness may have contributed to this discrepancy [23]. Other studies reporting fat loss used densitometry and dual X-ray absorptiometry [44,45]. However, the reported changes in body fat and fat-free or lean body mass were calculated from actual determinations that were adjusted empirically such that self-reported increases in physical activity were interpreted as fat loss and lean body gain. Thus, the validity of the reported positive effects of chromium supplementation on changes in body composition is highly questionable [28,44,45].

The present study found no independent effects of chromium picolinate supplementation on body weight or composition. This finding is consistent with the results of studies

using a variety of body composition assessment methods and physical activity interventions but without control of diet [8,9,46]. The present findings are novel because they were determined under conditions of known and controlled energy and nutrient intakes. Knowledge of energy and nutrient intake is fundamental because uncontrolled food intake affects body weight and composition independently of chromium intake [16].

A limitation of the present findings is the decrease in body weight in all groups (Table 2). Examination of the number of women in each group who required changes in food intake to remain within the tolerance of 2.5% of baseline body weight shows an interesting finding. Dietary caloric intervention was required statistically more frequently in the placebo group (13 of 29) than in the chromium picolinate (5 of 27) and picolinic acid (4 of 27) groups ($P < 0.05$, Fisher's exact test). Average energy intake at the end of the study was not different across the treatment groups (2255 ± 33, 2311 ± 33, and 2286 ± 33 kcal/d for the placebo, chromium picolinate, and picolinate supplemented groups). Thus, factors inherent in maintaining caloric balance, including variable physical activity, apparently were more influential in affecting body weight than supplementation with chromium picolinate.

Controlled intake of chromium in the present study also is an advantage over previous studies. Most previous studies only provided chromium supplements with no estimation of concurrent dietary chromium [8,9]. Only a few studies provided a diet with consistent chromium content but only for a few days before strength and biochemical assessments [32,33]. Dietary chromium in the present study was 25 to 30 μg, which is consistent with the current recommended intake for women [19]. Thus, the effects of supplemental chromium on body structure can be evaluated in comparison with the general recommendation to the public. Because no independent effects of chromium supplementation (200 μg/d) of a diet adequate in chromium were found on body composition, the present findings support the current recommended intake of chromium in women.

It is noteworthy that serum chromium concentrations increased in some groups (Fig. 1). Among the women supplemented with chromium picolinate, this finding is consistent with current models of chromium absorption; large intakes of chromium are associated with small changes in circulating chromium concentrations [47]. Interestingly, women supplemented with picolinic acid consumed the recommended intake of chromium (~29 μg) and experienced a transient and significant increase in serum chromium compared with the women consuming the same diet and supplemented with placebo. This observation suggests that some of the women were not consuming the recommended intake of chromium before their participation in the study. Thus, serum chromium is a specific indicator of chromium intake; its sensitivity remains questionable. Urinary excretion of chromium also increased (Fig. 2) in response to dietary and supplemental chromium. This result was expected because of the homeostatic response to increased chromium intake with chromium supplementation [48].

The effects of chromium picolinate supplementation on body weight and composition of adults with type 2 diabetes also have been described. No change was found in the body weights of men and women supplemented with 200 to 1000 μg/d for 4 mo despite significant improvements in glycated hemoglobin, cholesterol, glucose, and insulin [49]. Similarly, obese adults at high risk for type 2 diabetes had increased insulin sensitivity after 8 mo of supplementation with chromium picolinate (1000 μg/d) but no changes in body weight or abdominal adipose tissue distribution [50]. These results are consistent with the findings of the present study that supplemental chromium, even in individuals with insulin insensitivity, does not affect body weight or composition.

Supplementation with chromium picolinate has the potential to lead to nutritional disturbances. Absorbed chromium is transported principally on transferrin and to a lesser extent on albumin [10,51]. Chromium competes with iron for the two binding sites on transferrin [52]. In vitro studies showed that chromium reduces iron binding to transferrin [53]. Rats fed very high doses of chromium had significantly reduced transferrin saturation, depleted tissue iron storage, and decreased hemoglobin [12]. The present study, however, did not find evidence of reduced iron transport or utilization during supplementation with 200 μg of chromium for 12 wk. This dose of supplemental chromium, in the presence of adequate chromium intake, apparently was not detrimental to iron metabolism. This finding is consistent with the report of Campbell et al. [15] who supplemented men with 1000 μg of chromium daily for 8 wk and found no changes in hematology or other indicators of iron status. However, other studies in adults consuming self-selected diets and supplemented with chromium picolinate reported 20% to 30% decreases in serum ferritin concentrations [14,42], which were within the range of normal values. Large between-subject variability in serum ferritin response contributed to a lack of statistical significance. Thus, the effect of chromium supplementation (200–1000 μg/d for 12 wk) on measurements of iron status in adults with adequate iron status appears to be modest.

Chromium is a very popular dietary supplement. From 1996 through 2003, sales of chromium supplements increased from $65 to $106 million in the United States, which represents >6% of all mineral supplement sales [54]. Chromium picolinate is the principal form of supplemental chromium sold, accounting for 80% of all chromium sales. It is sold individually as chromium picolinate or as a component of herbal blends or mixed formulae with vitamins, minerals, or other bioactive ingredients. Chromium as chromium picolinate also is provided in nutrition bars, chewing gum, and sports drinks. This market demand is influenced by the claims that chromium picolinate facilitates weight loss and selective fat loss and lean body gain.

In summary, the findings of the present study do not support the hypothesis of an independent effect of chromium, as chromium picolinate, on propitious changes in body composition of women fed the recommended daily intake of chromium. They provide the first evidence to support the court ruling [55] of no basis for the claim that chromium supplements per se promote weight loss and fat loss in humans, regardless of presence or absence of insulin sensitivity. The findings also demonstrate no adverse effect of chromium picolinate supplementation on the iron status of adults. Continued claims that chromium picolinate supplements independently promote weight loss and body composition change are without basis.

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